



Plastic ingestion by Procellariiformes in Southern Brazil

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ABSTRACT

The Procellariiformes are the birds most affected by plastic pollution. Plastic fragments and pellets were the most frequent items found in the digestive tract of eight species of Procellariiformes incidentally caught by longline fisheries as well as beached birds in Southern Brazil. Plastic objects were found in 62% of the petrels and 12% of the albatrosses. The Great shearwater, Manx shearwater, Cory's shearwater and Antarctic fulmar were found to have greater quantities and frequencies of occurrence of plastic. There was no significant difference in the number of plastics between the birds from longline fisheries and beached birds. No correlation was found between the number of prey and number of plastics in the digestive tract of the birds analyzed, but this does not discard the hypothesis that, in some cases, the presence of plastic in the digestive tract has a negative effect on the feeding efficiency of these birds.

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1. Introduction

Plastics are strong, light objects that can float on the ocean surface (Morris, 1980) and are often found in the stomach contents of a variety of albatrosses and petrels (Procellariiformes) (Huin and Croxall, 1996; Fry et al., 1987). Two classes of plastic are most found in Procellariiformes (Ryan, 1987): plastic pellets and fragments. Pellets are an intermediate stage in the manufacturing process of plastic (Colton et al., 1974), which are lost during manufacturing or transportation. These objects enter the marine ecosystem either directly or through drainage systems and are spread throughout the oceans on currents (Furness, 1983). Plastic fragments are small pieces broken off from larger items (fishing buoys, buckets and bottles), which are either discarded or lost at sea by fishing boats and other types of vessels (Merrell, 1980). Other ingested anthropogenic items include toys, polystyrene, monofilament lines, rubber and plastic tape (Robards et al., 1995).

In the Northern Atlantic, Procellariiformes are the birds that are most affected by the pollution of plastic particles (Moser and Lee, 1992), harmed through the digestion of these items due to the inability to regurgitate them (Furness, 1985b; Azzarello and Van Vleet, 1987). Plastic particles can remain in the ventriculus for months or even years before being completely eliminated (Furness, 1985a; Ryan, 1988).

Studies carried out on the extent of the effects of plastic ingestion by birds suggest that there may be a reduction in digestive

capacity caused by the reduction in functional volume of the proventriculus and ventriculus, leading to a loss of energy reserves for migration and nidification (Connors and Smith, 1982; Furness, 1983, 1985b; Ryan, 1988). Other harmful effects are also cited, such as intestinal obstruction and ulcerations (Bourne, 1976; Bourne and Imber, 1982), blockage of gastric enzyme secretion (Azzarello and Van Vleet, 1987) and absorption of organochlorine adsorbed by the plastics (Carpenter et al., 1972; Ryan et al., 1988), which can cause reproductive failure and death (Azzarello and Van Vleet, 1987; Ryan et al., 1988; Lee et al., 2001).

Approximately 40 species of Procellariiformes from the Northern and Southern hemispheres use Brazilian waters as a feeding area during migration season (CBRO, 2006). Anthropogenic factors such as fisheries and marine pollution threaten these species, which are of great conservation interest due to the steep decline in their populations in recent decades (Croxall et al., 1998; Croxall and Gales, 1998; Ryan, 1998).

In the present study, we first evaluated the presence of plastics in the digestive tract of Procellariiformes incidentally caught by longline fisheries as well as beached birds in Southern Brazil. We then assess the differences in plastic ingestion between beached birds and birds killed by fisheries and test the hypothesis that the presence of plastic may lead to a decrease in food ingestion by seabirds.

2. Methodology

A total of 193 birds, including 59 Black-browed albatrosses (*Thalassarche melanophris*), 27 Atlantic Yellow-nosed albatrosses (*T. chlororhynchos*), 41 White-chinned petrels (*Procellaria*

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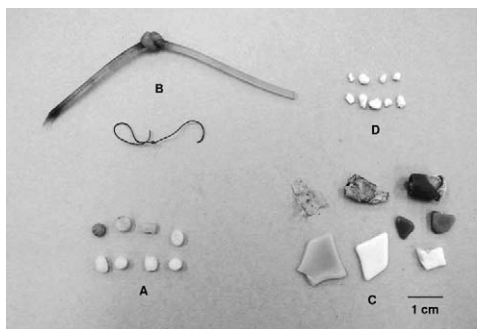


Fig. 1. Plastics categories found in the digestive tract of Procellariiformes. The plastic pellets (A) were found in the ventriculus of Great shearwater. The plastic line used in longline fisheries, the nylon (B) and the hard and flexible plastic fragments (C) were found in the digestive tract of beached Great shearwater and Antarctic fulmar specimens. The polystyrene (D) were found in the ventriculus of Black-browed albatross.

aequinotialis), 9 Spectacled petrels (*P. conspicillata*), 18 Great shearwaters (*Puffinus gravis*), 25 Manx shearwaters (*P. puffinus*), 9 Atlantic fulmars (*Fulmarus glacialis*) and 5 Cory's shearwaters (*Calonectris diomedea*), were collected between 1994 and 2005 by the team of the Museu Oceanográfico do Vale do Itajaí (MOVI) and the Fundação Universidade Federal do Rio Grande (FURG). In this sample, 115 birds were found dead on beaches in the state of Rio Grande do Sul (29°S to 33°S) and 78 were incidentally caught by pelagic longline fisheries operating in Southern Brazil.

The collected birds were autopsied and food items in the proventriculus, ventriculus and intestine were preserved in 70% alcohol and the number of prey items counted. The number of fish prey in each specimen was obtained by the maximum number of entire prey items, hypural bones or the number of pairs of otoliths or eye lenses found. The number of cephalopod prey was determined from the maximum number of either upper or lower beaks of each species or the number of pairs of eye lenses found.

Plastics found in the digestive tract of the birds were separated into four categories: plastic fragments, which are rigid pieces of larger objects or pieces of plastic bags and packaging either discarded or lost at sea; pellets, which have either polyethylene or polypropylene as the raw material in the form of small spheres or cylinders; nylon line; and polystyrene (Fig. 1). All plastics were cleaned, dried at room temperature and measured.

The relative frequency of occurrence (FO%) and number proportion (Nr%) were determined for each type of plastic. Non-parametric statistics (StatSoft Inc., 1996) at a significance level of 0.05 were used to test the significance of all comparisons. The Mann-Whitney test for independent samples was applied to test differences between the number of plastics in the stomach contents of beached birds and birds caught in longline fisheries.

In order to test the hypothesis that the presence of plastics in the digestive tract causes a reduction in food intake, the correlation between the number of plastics and prey found in the digestive tract (proventriculus and ventriculus) of the birds was determined using Spearman's rank correlation.

3. Results

Plastic objects were found in 38.3% ($N = 74$) of the birds sampled, principally fragments, pellets and lines. Only 7.2% of these birds ($N = 14$) had no food items in their digestive tracts.

The average number of plastics did not exceed the average number of prey found in proventriculus and ventriculus for most species (Fig. 2). Exceptions occurred for Manx shearwater and Antarctic fulmar in which plastics amount to approximately 83% and 54%, respectively, of the total items (plastic and prey). However,

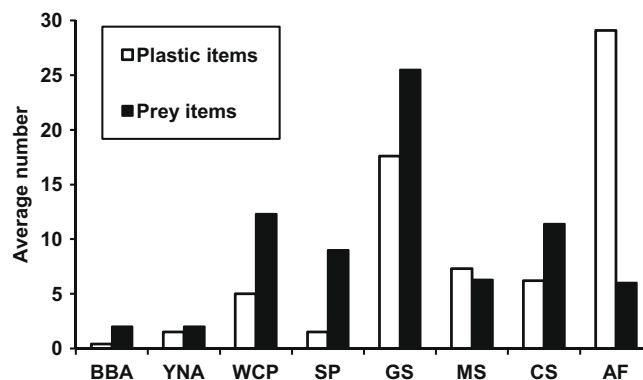


Fig. 2. Average number of plastic items and prey items found in the proventriculus and ventriculus of the Black-browed albatross (BBA), Atlantic Yellow-nosed albatross (YNA), White-chinned petrel (WCP), Spectacled petrel (SP), Great shearwater (GS), Manx shearwater (MS), Cory's shearwater (CS) and Antarctic fulmar (AF).

there was no significant correlation between the number of plastics and the number of prey found in the digestive tract of any of the species studied ($r_s = -0.4$ to 0.6 ; $p > 0.05$).

Plastics occurred in 62% of the petrels (Procellariidae), whereas the frequency of occurrence of plastics was 12% in albatrosses (Diomedidae). Most of the plastics found in the albatrosses (Black-browed and Atlantic Yellow-nosed) were in the proventriculus. Just one plastic (flexible fragment) was found in the intestine of the Black-browed albatross. The petrels had a higher quantity of plastic items in the ventriculus (Fig. 3).

The frequency of occurrence (FO%) of plastics in each of the species studied was as follows: 12% for the Black-browed albatross, 7% for the Atlantic Yellow-nosed Albatross, 49% for the White-chinned petrel, 22% for the Spectacled petrel, 89% for the Great Shearwater, 60% for the Manx shearwater, 100% for Cory's shearwater and 79% for the Atlantic fulmar. The FO% of plastics was 35.3% for the birds found dead on the beach and 48.8% for birds caught by longline fisheries. Birds collected from the beach did not have a significantly higher number of ingested plastics than those caught by longlines ($U = 339.5$; $p > 0.05$).

In the entire sample fragments and pellets were the most frequent items found, with FO% of 74.3% and 45.9%, respectively. Plastic fragments were the objects with the highest FO% and Nr% in six

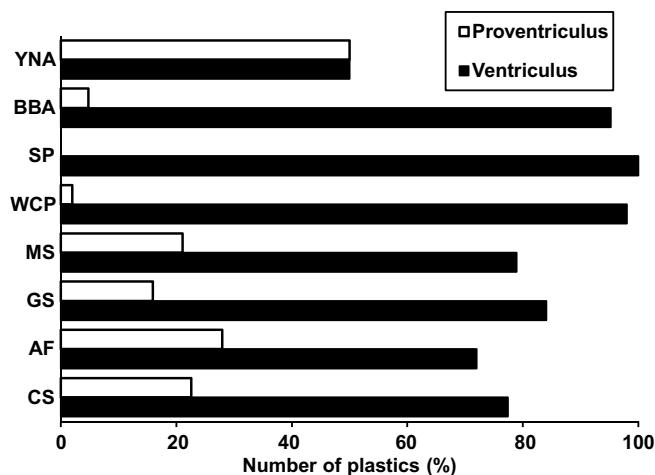


Fig. 3. Percentage of plastics found in the proventriculus and ventriculus of the Black-browed albatross (BBA), Atlantic Yellow-nosed albatross (YNA), White-chinned petrel (WCP), Spectacled petrel (SP), Great shearwater (GS), Manx shearwater (MS), Cory's shearwater (CS) and Antarctic fulmar (AF).

of the eight species studied. The Great shearwater, Manx shearwater, Cory's shearwater and Antarctic fulmar had the highest amounts and frequencies of occurrence of plastics. No pellets were found in the digestive tract of Black-browed or Atlantic Yellow-nosed albatrosses (Fig. 4). Polystyrene occurred only in 5.4% of the birds (three Antarctic fulmars and one Black-browed albatross) and represented 2.6% in number of plastics.

One Great shearwater specimen found on the beach had 40 fragments and pellets in the proventriculus and 32 in the ventriculus.

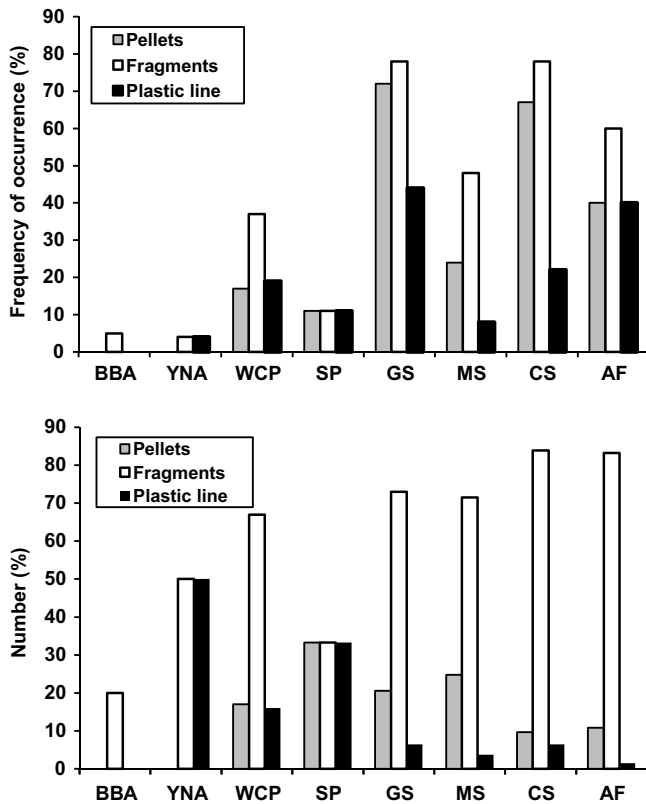


Fig. 4. Relative frequency of occurrence (FO%) and number (N%) of the main plastics found in the digestive tract of the Black-browed albatross (BBA), Atlantic Yellow-nosed albatross (YNA), White-chinned petrel (WCP), Spectacled petrel (SP), Great shearwater (GS), Manx shearwater (MS), Cory's shearwater (CS) and Antarctic fulmar (AF).

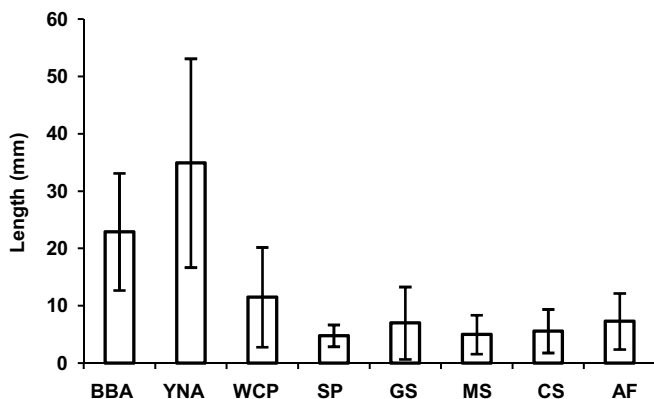


Fig. 5. Lengths of plastics found in the digestive tract of the Black-browed albatross (BBA), Atlantic Yellow-nosed albatross (YNA), White-chinned petrel (WCP), Spectacled petrel (SP), Great shearwater (GS), Manx shearwater (MS), Cory's shearwater (CS) and Antarctic fulmar (AF).

Most of the plastics were sharp and of different shapes and sizes. One piece was obstructing the passage from the esophagus to the proventriculus.

Sizes of the plastics found in Black-browed and Atlantic Yellow-nosed albatrosses were larger than those found in the other species of Procellariiformes studied. Among the petrels, the White-chinned petrel, Great shearwater and Antarctic fulmar had the largest average size of plastics (Fig. 5).

4. Discussion

Among seabirds, Procellariiformes have the highest incidence of ingested plastic particles (Bourne, 1976). Young and adult albatrosses are able to regurgitate indigestible material found close to the nest (Clarke and Prince, 1981; Clarke et al., 1981), but there are no reports of this ability for petrels (Furness, 1985a). In most petrels, a narrow constriction between the proventriculus and the ventriculus prevents particles to be regurgitated, and these birds can accumulate dozens of solid materials in the ventriculus, such as cephalopod beaks (Warham, 1996; Colabuono and Vooren, 2007). This may explain the lower occurrence of plastics in the digestive tract of albatrosses than in petrels as well as the higher incidence of these objects in the ventriculus of petrels.

Great shearwaters, Manx shearwaters, Cory's shearwaters and fulmars are among the Procellariiformes with the highest frequency of plastic ingestion; whereas the occurrence of plastics in Black-browed and Yellow-nosed albatrosses is lower (Furness, 1985a; Furness, 1985b; Ryan, 1987; Moser and Lee, 1992). This difference was corroborated in the present study. Black-browed and Yellow-nosed albatrosses had similar frequencies of occurrence of plastics as those found by Ryan (1987) in Southern Africa and the African sector of the Southern Ocean. Great shearwaters, Manx shearwaters and Cory's shearwaters had a higher occurrence of plastics in the present study carried out in the Southern Atlantic than occurrences reported by Moser and Lee (1992) for the Northern Atlantic.

Plastic fragments and pellets were the most frequent items found in the digestive tract of the eight species studied. Most of these plastics have lower densities than sea water and therefore float on the ocean surface (Morris, 1980). All eight species studied feed on prey caught either at or near the surface as well as animals that float after dying and fishery discards (Prince and Morgan, 1987; Cherel and Klages, 1997; Colabuono and Vooren, 2007). These birds may ingest plastics because they confuse them for prey. As these species also follow boats, plastics floating around these vessels, including monofilament line, may have been ingested along with discards. Some of these items may have been ingested through secondary consumption, such as pellets found in the digestive tract of diverse species of fish (Carpenter et al., 1972; Anon, 1975; Kartar et al., 1976).

The average size of the plastic particles found in the albatrosses was greater than that found in the petrels. According to Fry et al. (1987), albatrosses are at risk for ingesting large plastic fragments from 2 to 20 cm in length. Petrels have a greater risk of consuming small pieces of plastic. However, the absence of small objects, such as pellets, in the albatrosses does not mean these birds do not ingest such objects, as small pieces of plastic can pass through the intestines of albatrosses more easily than in the smaller petrels due to the size of the digestive tract.

Although the birds caught by longline fisheries had a greater frequency of occurrence of plastics than those collected from the beach, there were no significant differences in the number of plastics between the two samples. After examining the stomachs of birds found dead on the beach, Bourne and Imber (1982) suggest that famished individuals must frequently ingest anthropogenic items. It is possible that, if the birds do not regurgitate solid items,

which then accumulate, such items may interfere in the digestive process. Cases definitively attributing seabird mortality to plastic ingestion are rare. Seabirds that die from ingestion often suffer obstruction of the gastrointestinal tract (Pierce et al., 2004). Cases such as the Great shearwater in the present study, in which plastic had obstructed the passage of food, have been reported for the Great shearwater and Northern Gannet (*Morus bassanus*) in Massachusetts, where these birds died from starvation (Pierce et al., 2004).

The lack of a correlation between the number of plastics and the number of prey found in the digestive tract of the birds studied here does not discard the possibility that the presence of plastics in the digestive tract affects the food intake of birds. A number of authors suggest that when birds ingest plastics, there is a reduction in feeding efficiency, negatively affecting energy reserves (Connors and Smith, 1982; Ryan, 1987; Spear et al., 1995). This probably occurs in cases in which there is a very high amount of accumulated plastics or when large objects are present. The accumulation of indigestible parts from prey in the digestive tract may also mask this type of result.

The ingestion of plastics by albatrosses and petrels can cause direct harm to individuals, such as obstructions, suffocation, internal injuries and death (Pierce et al., 2004). However, there are other factors, such as the absorption of pollutants through the ingestion of plastics which act as accumulators of organic pollutants in the marine environment (Mato et al., 2001; Bourne and Imber, 1982). Pollutants, such PCBs and DDE have an affinity to organic and plastic particles, in which they tend to be adsorbed (Mato et al., 2002; Endo et al., 2005; Rios et al., 2007). Studies on the transference of organic pollutants through the ingestion of plastics in seabirds are important to the understanding of this process.

The accumulation of plastic objects in the digestive tract over long periods of time may indirectly affect the life cycle of species and their reproductive success, with long-term harm caused to Procellariiformes populations.

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